were grown by a modified Bridgman technique. The materials used in this investigation were high purity copper of 99.9 per cent purity and nickel pellets of 99.95 per cent purity with iron as the major impurity. The furnace core consisted of a graphite resistor tube with a reduced cross-section which produced a sharp temperature gradient in the furnace. The specimen was contained in a ceramic crucible with a conically-shaped bottom which was supported within the furnace

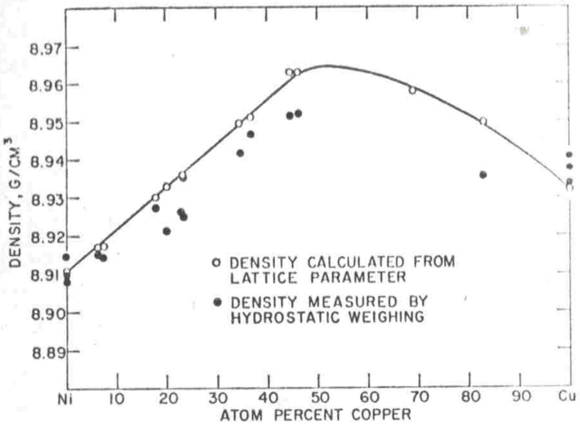

FIG. 1. Theoretical and measured densities of nickel–copper alloy single crystals.

by a tantalum rod connected to a positioning arm by means of which the crucible was raised and lowered through the temperature gradient. Graphite crucibles were used for the pure copper crystals, while BeO crucibles were utilized for nickel and all of the alloy crystals. A more detailed description of the apparatus and the technique employed for growing these crystals is given in a report by Armstrong and Carlson.[15]

Single crystals approximately 3 cm in diameter and 2.5 cm in length, exclusive of the conical bottom section, were obtained for all compositions. Their orientations were determined by a Laue back-reflection X-ray technique and plates were cut with faces oriented for either the [100] or [110] crystallographic direction. Plates intended for pulse-echo measurements were cut to a thickness of from 0.5 to 2 cm while those for resonance measurements were less than 0.25 cm thick. All the plates were carefully hand lapped and polished, to produce faces deviating less than 0.001 cm from parallelism and aligned to within 2 degrees of the desired crystallographic axis.

Chemical analysis of samples taken from upper and lower regions of the ingots revealed no detectable concentration gradients; however, in most instances the actual composition was from 2 to 4 per cent off from the intended composition due to the vaporization of copper.

Alloys containing up to 30 at.% Cu were observed to exhibit ferromagnetic behavior at room temperature. Curie temperatures determined for pure nickel and the nickel-rich alloys were in good agreement with values reported by Krupkowski[16] and Marian.[17] In the as-grown condition these alloys showed a rather sluggish transition from the ferromagnetic to paramagnetic states probably due to coring or micro-segregation. However, after annealing for 200 hr at approximately 1100°C in a helium atmosphere these same specimens exhibited a sharp transition temperature.

The lattice parameter was determined for each alloy from X-ray powder patterns and its density was calculated therefrom. A comparison of the alloy densities thus determined with those obtained by hydrostatic weighing is given in Fig. 1. These data are in good agreement with those obtained from lattice parameter values reported by Coles[18] for Ni–Cu alloys particularly at the nickel-rich end of the system. The calculated density represented by the data points in the figure was used in the elastic constant calculations.

The adiabatic elastic constants were determined from ultrasonic velocities measured by the pulse-echo method. The basic apparatus and techniques employed in this investigation are described in a previous Ames Laboratory report.[15] An important modification of this apparatus was the substitution of a Tektronix type 545 oscilloscope with a self-contained sweep delay for the original external sweep-delay to measure elapsed time between the echos generated by the 10 megacycle pulse. Quartz piezoelectric transducers, ½in. square and gold-plated on one face, were acoustically bonded to the single crystalline plates with phenyl salicylate (salol).

Transit times for the ultrasonic signals were measured for each specimen from echoes of the pulse at temperatures between −40 and 40°C. This experimental work was performed before Eros and Reitz[19] had published their experiments on elimination of the transit time error, hence a correction for the errors in transit time associated with the partial reflection and transmission of the ultrasonic pulse at the crystal–quartz interface was applied to the calculation of the elastic constants. The magnitude of this time delay was determined for longitudinal wave propagation by comparing the velocities obtained by the pulse-echo method with velocities measured by a resonant-frequency technique described by Bhagavantam and Bhimasenachar.[20] Since the latter method is only applicable to longitudinal vibrations, the transit time delay encountered with shear waves was determined by the measurement of transit times in plates of